Deployment of Calibration Sources in the KamLAND Detector

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1 Introduction

At present, KamLAND detector calibration and monitoring with calibration sources is carried out according to the following scheme. On a weekly basis, a gamma source (usually Co–60) is deployed at a few positions along the z–axis. The data from these weekly deployments are promptly analyzed on–site to measure changes in energy and vertex reconstruction. These weekly data are also used to update the calibration tables (occupancy, gain, and relative timing) used by event reconstruction in the US analysis. After any change to the detector, at least one gamma source is deployed to gauge the impact of the change; if the change is known to be significant, a combination of gamma and neutron sources, the US laser, and the Japan laser is deployed at multiple positions. The latter is a so–called full calibration. Until now, all full calibrations have been triggered by known changes in the detector hardware although in principle full calibrations could also be triggered by significant changes in detector response detected through the weekly deployments. Deployment of any source must be preceded by appropriate certification of the source and preparation of the source and deployment system according to well-defined procedures.

Within the next few months, some changes significantly impacting calibration will take place. One change is that personnel fully trained in the preparation of sources and operation of the deployment system will no longer be present full-time on the site. A second change is that the deployment system will be upgraded to allow calibration sources to be positioned off-axis. It should be noted that, as part of this upgrade, the motorized winch and associated controls presently used for z–axis deployments will be removed, and subsequent z–axis deployments will use one of the winches installed for off–axis deployments. The purpose of this note is to define how detector calibration will continue with these changes in place.

We will make a distinction below between three types of source calibration. The first type

of calibration is a so–called *routine calibration*. In such a calibration, a single source, which is already attached to the the z–axis deployment system, is deployed at a small number of positions. Only the controls for the glovebox purging, gate valves, and winch motor have to be operated. The second type of calibration is the so–called *full z–axis calibration*. In this calibration, multiple sources (radioactive, laser, LED,...) are deployed at various positions on the z–axis. In this type of calibration, sources must be transferred into, and out of, the glovebox with appropriate measures taken to prepare the sources for introduction into the glovebox clean room. The third type of calibration is the *4π calibration*, in which various calibration sources are deployed off–axis.

The remainder of this note is organized as follows. First, we specify the nominal frequency at which specific types of calibrations will be carried out. Second, we define basic procedures which must be followed in carrying out any source calibration. Third and finally, we indicate the responsible people for various aspects of source calibration.

2 Calibration Frequency

2.1 Routine calibration

Routine calibrations will be carried out periodically using the composite source (Ge–68/Co–60). The calibration frequency will be twice/month initially with the aim of reducing the frequency to once/month eventually. The source will be positioned in turn near the bottom of the detector, the center of the detector, and near the top of the detector. Data from routine calibrations will be reconstructed and analyzed within two days of being acquired.

At a minimum frequency of once/week, at least one day of normal data will be reconstructed on–site for monitoring purposes. The results of the monitoring data analysis will be used by the US analysis to interpolate calibration tables between routine calibrations for the case of gradual variations in detector response.

In the event there is a change to the detector hardware whose impact on the data integrity is unknown, a routine calibration will be carried out as soon as possible to gauge the magnitude of its effect.

2.2 Full z–axis calibration

A full z-axis calibration will be carried out whenever at least one of the following conditions occurs:

1. It is no longer possible, using routine calibrations and normal data monitoring alone, to control the stability of (a) the energy reconstruction to 0.5% or (b) the determination of the fiducial volume to 1.0%.

2. There is a change to the detector whose impact on event reconstruction is expected to be significant.

3. It has been 4 months since the previous full z–axis calibration or 4π calibration.

Concerning Condition 1, the uncertainties in energy reconstruction and determination of the fiducial volume receive a contribution from uncertainties in the time variation of calibration constants. It is the responsibility of those carrying out the analysis of routine calibration data and normal data for monitoring purposes to estimate when the impact of uncertainties in time variation reaches the levels indicated for energy reconstruction and determination of the fiducial volume.

2.3 4π calibration

A 4π calibration should be performed as soon as possible. We will be in a better position to estimate the required frequency of 4π calibrations once we have the experience of the initial 4π calibration, but it is expected that no more than two will be needed per year.

3 Procedures

Procedures followed in source calibration involve the *calibration committee*, *calibration coordinator*, *calibration liason*, and *calibration system operators*:

- The calibration group has delegated to the *calibration committee* final authority for all policies and procedures concerning detector calibration with sources. This includes certification of sources, maintenance of sources on–site, and deployment of sources.

- The *calibration coordinator* is responsible for planning source calibrations and seeing to it that they are executed in a timely way according to approved policies and procedures. It is the responsibility of the calibration coordinator to see to it that written and up–to–date documentation on calibration procedures exists and that checklists are drawn up for common calibration tasks and followed. The calibration coordinator is nominated by the calibration committee and approved by the collaboration.

- The *calibration liason* is based at the experiment and acts as the representative of the calibration coordinator when the calibration coordinator is not based on–site. The on–site calibration liason represents the interests of calibration in scheduling meetings and monitors calibration activities on–site.

- The *calibration system operators* perform the source calibrations based on their expertise and level of training.

For any new source proposed for KamLAND calibration, its certification must be reviewed and approved in writing by the calibration committee before it can be brought to the site. Procedures for on–site storage and deployment of each source must be documented and followed.

Source calibration, whether it be a routine calibration, a full z–axis calibration, or a 4π calibration, can be performed only by calibration system operators with the appropriate level of training. Only collaborators certified by the calibration coordinator and approved by the calibration committee may participate as operators in source calibrations. Written documentation for each aspect of the calibration must be available to the operators, and the operators must follow the appropriate checklist. It is the responsibility of the group which built the source or deployment system to see to it that the operators are adequately trained and documentation provided.

Any source calibration must be approved by the calibration coordinator and communicated to the on–site coordinators and calibration liason at least one day in advance of the proposed calibration in the case of a routine calibration and at least one week in advance of any other kind of calibration. The calibration committee must be informed of any calibration request. All source calibrations are subject to final approval by the on–site coordinators.

The calibration coordinator has responsibility for ensuring that calibration data is analyzed in a timely way and incorporated as appropriate into the event reconstruction. A database will be set up that describes each calibration and the status of its analysis.

4 Responsibilities

We nominate the following persons and groups to accept the responsibilities described above. (All individuals nominated below have indicated their willingness to accept the proposed responsibilities.)

1. Herb Steiner and Jerry Busenitz to constitute the calibration committee.
2. Evgueni Yakushev to serve as calibration coordinator.
3. Kengo Nakamura to act as calibration liason in the absence of Evgueni Yakushev on–site.
4. Calibration system operators: Evgueni Yakushev and Tim Classen are fully trained in the use of the glovebox and z–axis system and the preparation of sources for deployment. For the forseeable future, they will maintain this level of training for full z–axis calibrations and will travel to the site to prepare for and carry out any full z–axis calibration. For complex sources such as the laser systems, it is assumed that, as in the past, source experts will work with the trained glovebox and deployment system operators to carry out the calibrations. For carrying out routine calibrations, Kengo Nakamura and Shuichiro Hatakeyama will be trained. The Tohoku group has kindly

volunteered to provide 3 students to be trained to carry out one routine calibration per month. Thus one routine calibration each month will be carried out by one of the Tohoku students and the other routine calibration will be carried out by either Shuichiro or Kengo. Routine calibrations that must be carried out at short notice will be the responsibility of the calibration liason. Every opportunity will be taken to train additional collaborators for routine calibrations to maintain an adequate pool of manpower as people leave the experiment or move on to other responsibilities.

5. It is the responsibility of the US groups and of the UA group in particular to see to it that routine calibration data and normal data used for monitoring are analyzed in a timely way and incorporated as appropriate into calibration tables.